19

Biting Insects

19.1 Background

One of the most significant impacts of construction in or adjacent to tidal areas is the potential for the creation of new biting insect breeding sites (Northern Territory Coastal Management Committee [CMC], 1988).

The northern salt marsh mosquito *Aedes vigilax* and the common banded mosquito *Culex annulirostris* are known to occur in seasonally high numbers at East Arm Port (Warchot & Whelan 2010). Both species are known vectors of Ross River virus (RRV) and Barmah Forest virus (BFV), with the latter a known vector of the potentially fatal Murray Valley encephalitis virus (MVEV) and other arboviruses.

High numbers of the receptacle breeding mosquito *Aedes notoscriptus* have also been collected at East Arm. This species can transmit RRV and BFV, while breeding of this species also indicates ample available receptacles, and the potential for favourable breeding sites, for exotic dengue mosquitoes (*Aedes aegypti*) (Warchot and Whelan, 2011).

The East Arm area is also subject to very high seasonal biting midge pest problems, caused by the mangrove biting midge *Culicoides ornatus* (Warchot & Whelan 2006). Breeding sites are associated with the nearby Bleesers Creek and Hudson Creek, which surround the East Arm Port Area (Warchot and Whelan, 2011).

Due to the known biting insect issues affecting the site, a biting insect investigation was recommended as part of the Environmental Assessment process for the proposed expansion of EAW. Medical Entomology of the NT Department of Health (DOH) was commissioned by URS to conduct this assessment. This assessment included (Warchot and Whelan, 2011):

- Conducting peak season biting midge trapping throughout the East Arm Peninsular.
- Conducting a range of larval mosquito surveys to determine the breeding sites for salt marsh mosquitoes and other pest and vector mosquitoes.
- Evaluating previous biting insect reports on the East Arm area and incorporating relevant information into the current assessment.
- Evaluating development concepts for the potential to create new mosquito breeding sites.
- Providing recommendations on rectifying existing mosquito breeding sites, and preventing the creation of new mosquito breeding sites.
- Providing recommendations on minimising the impact of biting midges on the workforce.

Six traps designed to catch both biting midges and mosquitoes were set around the East Arm Port area on the 23rd and 24th of October 2010. The trap sites were chosen to provide an even coverage of the East Arm Peninsular. Trap sites are shown in Figure 19-1.

Field surveys for potential mosquito breeding sites were conducted on the 11th of October 2010 and 31st of December 2010. The first field survey in October was conducted two days after the highest tide in the 2010 build up period, and was also the morning after heavy rainfall. The December survey was conducted 5 days after the largest daily rainfall event from the first monsoon event of the wet season. Survey sites identified as actual or potential breeding sites are shown in Figures 19-2, 19-3 and 19-4.

Source: Warchot and Whelan, 2011

Figure 19-1 Location of adult biting insect trap sites and potential biting midge (*C. ornatus*) breeding sites

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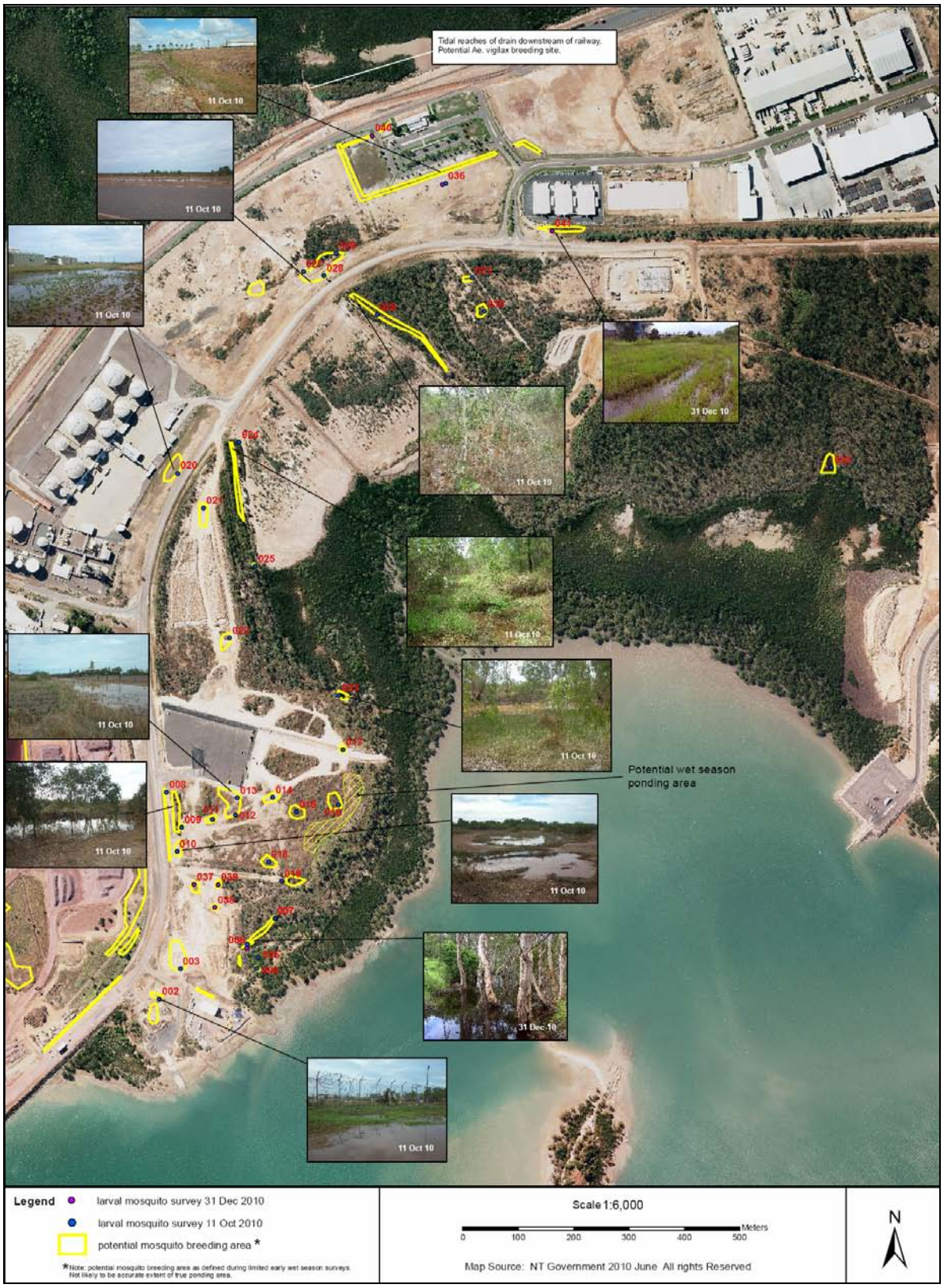
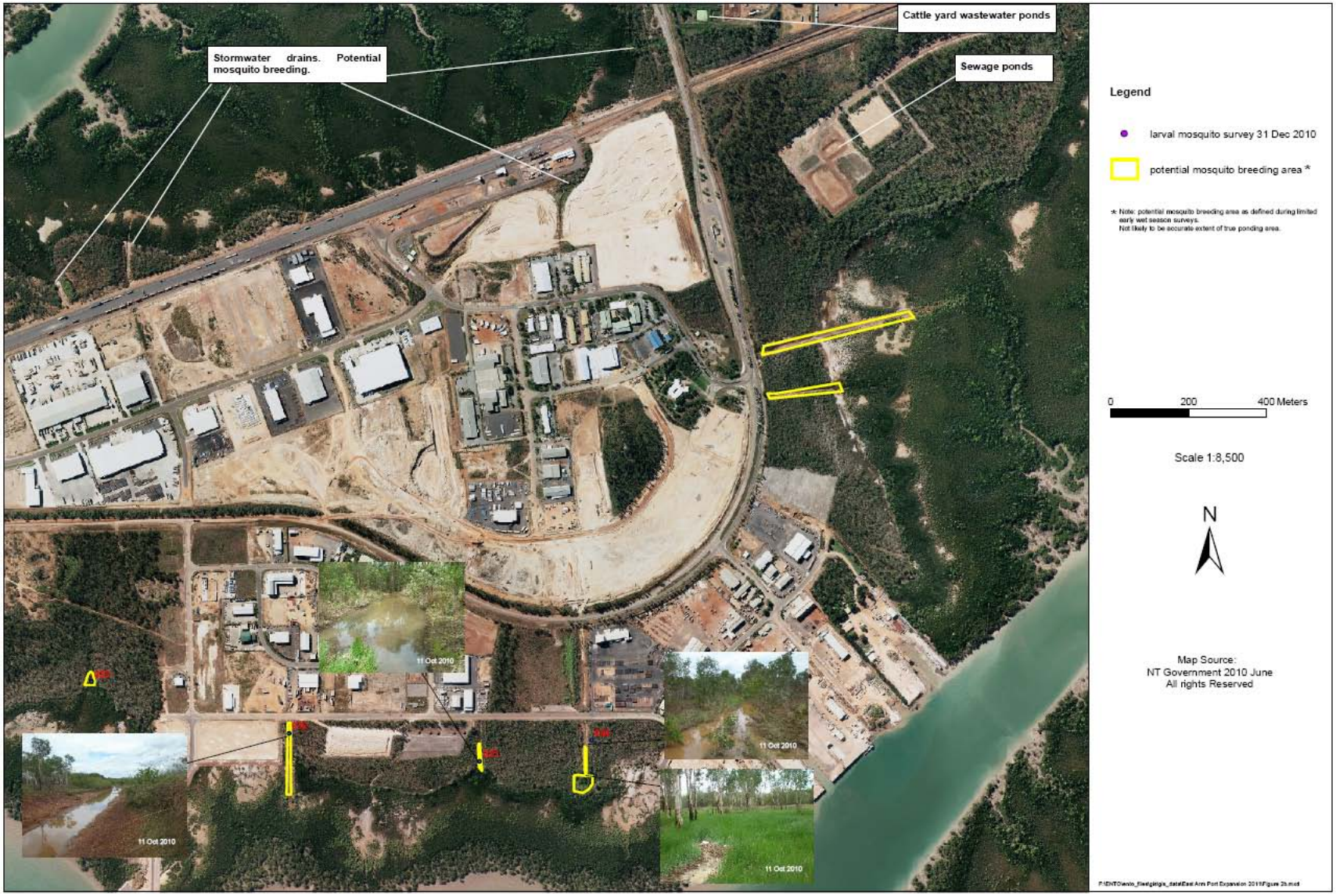


Source: Warchot and Whelan, 2011

Figure 19-2 Actual and potential mosquito breeding sites identified in surveys on 11 October and 31 December 2010



Source: Warchot and Whelan, 2011

Figure 19-3 Actual and potential mosquito breeding sites identified in surveys on 11 October and 31 December 2010

Source: Warchot and Whelan, 2011

Figure 19-4 Actual and potential mosquito breeding sites identified in survey on 31 December 2010

Results of routine mosquito trapping undertaken by Medical Entomology from February 2009 to February 2010 have also been included in this assessment. A trap site at the old East Arm boat ramp was monitored on a weekly basis for selected mosquito species in anticipation that the results would be used to advise this assessment. The aim of this routine monitoring program was to provide recommendations on reducing mosquito populations and breeding sites, to minimise the mosquito problem in the area.

Survey sampling methodologies and a full report on the results of the survey are presented in **Appendix O**.

19.2 Existing Environment

19.2.1 Mosquitoes

Mosquitoes are a serious potential public health issue in the NT, both as pest insects and as vectors of a number of human diseases including the potentially fatal disease caused by MVEV, and a number of other diseases caused by Kunjin virus (KUNV), RRV and BFV (Warchot and Whelan, 2011).

The East Arm area has been an appreciable mosquito breeding area since the development of the port, with major mosquito breeding associated with hill removal, borrow pits and scrapes, cut-off upper tidal mangrove areas, mud ponds and sediment ponds, constructed drainage lines, and shallow ponding on reclaimed land. All of these are artificially created breeding sites. Natural breeding sites at East Arm were previously limited to isolated upper tidal depressions (Warchot and Whelan, 2011).

The presence of very appreciable and productive mosquito breeding sites created by the first stage of development indicates future development has the very high potential to create new mosquito breeding sites. Future development also has the opportunity to rectify existing mosquito breeding sites. Rectification of existing mosquito breeding sites will be of benefit to workers in the East Arm Area, by reducing pest problems and the risk of mosquito borne disease transmission (Warchot and Whelan, 2011).

It is also noted that mosquito breeding sites also pose a risk passengers at the nearby rail terminal, and potential quarantine issues in regards to the International Health Regulations (Warchot and Whelan, 2011).

The most important mosquito species collected of public health importance at East Arm were the northern salt marsh mosquito *Aedes vigilax* and the common banded mosquito *Culex annulirostris*.

Other mosquito species of potential significance, either as disease vectors or pest mosquitoes, included the receptacle mosquito *Aedes notoscriptus*, the golden mosquito *Coquillettidia xanthogaster*, the brackish water mosquito *Verrallina funereal*, the salt water Culex mosquito *Culex sitiens* and Anopheles mosquitoes (Warchot and Whelan, 2011).

Results of the weekly trapping program undertaken by Medical Entomology from February 2009 to February 2010 of seven of these significant insect species are shown in Figure 19-5.*Verrallina funereal* was not included in this trapping program).

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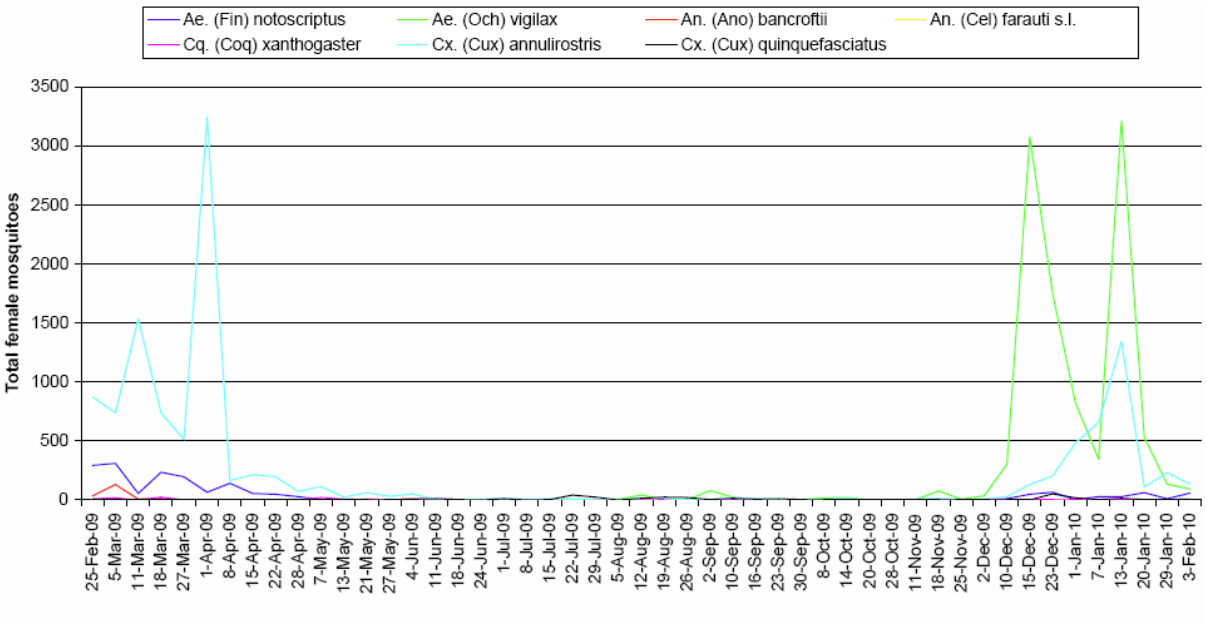

Source: Warchot and Whelan, 2011

Figure 19-5 Results of mosquito trapping undertaken of select mosquito species from February 2009 to February 2010 at old East Arm boat ramp

A description of breeding sites, abundance, distribution and biting habits of the *Ae. vigilax, Cx. annulirostris, Ae. notoscriptus,* and other mosquito species collected at EAW are presented in Table 19-1.

Detailed information on mosquito breeding areas created in the first stage of development is presented in Medical Entomologies report which is contained in **Appendix O**.

Table 19-1 Characteristics of the Aedes vigilax, *Culex annulirostris*, *Aedes notoscriptus*, and Other Mosquito Species Collected at EAW

Mosquito	Description
Aedes vigilax (northern salt marsh mosquito)	• Typical breeding sites include salt marshes, brackish water reed swamps, coastal interdune depressions, poorly draining upper tidal mangrove areas, tidally affected stormwater drains and disturbed upper tidal areas (Whelan 1997a). • Breeding sites at East Arm include depressions on reclaimed and disturbed land, sediment ponds and shallow mud ponds, stormwater drains subject to tide influence, and upper tidal depressions. • Most abundant from September to January (Whelan 1997a). • Has a very long flight range, capable of flying up to 200km, although highest numbers are usually encountered within 5 km of breeding sites (Whelan 1997a). • Will be the most important pest mosquito affecting East Arm. • An aggressive biter and will bite during the daytime in shaded areas as well as at night, and is usually the cause of most of the mosquito pest problems in Urban Darwin and Palmerston.
Culex annulirostris (common banded mosquito)	• Potential breeding areas include all shallow ponding areas with grass and/or semi-aquatic reeds, drains with semi-aquatic vegetation, and mud ponds and sediment ponds with semi-aquatic vegetation. • Most abundant from January to August (Whelan 1997), in which there is usually two peaks in abundance, a short early/mid wet season peak and an extended late wet-mid dry season peak, depending on the characteristics of nearby breeding sites. At East Arm, this

Mosquito	Description
	species will be most common from January to April. • Can disperse up to 10km from extensive breeding sites, although are most common within 4km of breeding sites (Whelan 1997a), and there is usually a significant drop in numbers 2 km away from significant breeding sites (Whelan 2004a). • Only bites after sundown at night, and is less aggressive than *Ae. vigilax*.
Aedes notoscriptus (receptacle breeding mosquito)	• Breeds in natural tree holes in undeveloped areas, and in almost any artificial receptacle in urbanised areas. • Levels in natural areas are usually low, with urban areas providing the greatest abundance of breeding sites. • This mosquito has a limited flight range and does not fly far from their breeding sites. • As a receptacle breeding mosquito, this mosquito generally has a wet season abundance. • Pest problems, when they occur, would be mainly in the evening.
Other mosquitoes (Anopheles mosquito, *Verrallina funerea, Culex sitiens*)	• *Anopheles* mosquitoes include some species that are potential malaria vectors. Their favoured natural habitat includes large reed swamps. At East Arm, breeding sites will include depressions and sediment ponds colonised by semi-aquatic reeds. • *Ve. funerea* would mainly be found breeding in brackish water paperbark depressions, tidally affected stormwater drains and any upper tidal mangrove depressions around East Arm. • *Cx. sitiens* is a saline water breeding mosquito, and may breed in Mud ponds, sediment ponds adjacent to tidal areas, upper tidal depressions, and tidally affected drains. • *Ve. funerea* and *Cx. sitiens* generally do not fly far from their breeding sites, but can be appreciable pest mosquitoes near to their respective brackish and saline water breeding sites.

Source: Warchot and Whelan, 2011

19.2.2 Midges

The mangrove biting midge *C. ornatus* accounted for the majority of biting midges collected during trapping at East Arm. All other biting midge species were recorded in low numbers only, or were not of any appreciable human pest significance (Warchot and Whelan, 2011).

Culicoides ornatus is considered the most significant human pest biting midge species around coastal areas of the NT (Shivas 1999, Shivas & Whelan 2001), and is also the most common biting midge pest around coastal areas of the NT (Whelan 2003).

Prime breeding sites include the upper tidal tributaries of mangrove creeks around the mean high water neap tide mark, associated with pneumatophores of the mangrove species *Avicennia marina*, with highest productivity during the mid to late dry season (Shivas 1999). Other breeding sites of low to medium productivity occur at the front edge of the mangrove forest in the *Sonneratia* or woodland mangrove zone facing open water (Shivas 1999). These breeding sites are usually associated with mud substrates (Shivas 1999).

Wet season breeding sites are also found in the Ceriops zone at the back of the creek bank forest, where moderate productivity occurs, and the Rhizophora zone upstream of the Sonneratia foreshore mangrove areas (Shivas 1999, Shivas & Whelan 2001).

Culicoides ornatus disperses inland from its mangrove breeding sites (Shivas 1999, Shivas and Whelan 2001). Mass movement of adults can occur to 0.5 to 1.5 km from the mangrove margin of their major breeding sites, with minor numbers up to 3km from the nearest mangrove margin (Whelan 2003). Greatest midge abundance is usually found at the top of the leading edge of escarpments facing their mangrove breeding areas within 1.5 km of the mangrove margin (Shivas & Whelan 2001).

The results of the studies undertaken to advise this assessment indicate that pest problems affecting East Arm will be severe in at least the outer edge of East Arm within 1 km of the mangroves of Bleesers Creek and Hudson Creek, and high throughout much of the rest of East Arm during August to November. During other months, high pest problems are likely to affect most of East Arm, particularly within 500 m-1 km of the nearest mangrove margin (Warchot and Whelan, 2011).

19.3 Potential Impacts

Biting insects have the potential to affect the health of workers and members of the public through the transmission of mosquito-borne diseases or reactions to bites. The potential for the spread of these mosquito borne diseases and reactions to biting midge bites to occur is discussed below in Section 19.3.1 Potential impact to health.

The proposed development has the potential to create additional mosquito habitats and hence increase mosquito populations. This is discussed further in Section 19.3.2 (Potential impacts on mosquito habitats).

The mangrove biting midge *C. ornatus* breeds in mud adjacent to and under dense mangrove canopies (Warchot and Whelan, 2011). It is not envisaged that the proposed development will result in any increases in mangrove areas, and therefore biting midges are not discussed in Section 19.3.2.

Although considered of minimal impact, the proposed development will result in the partial removal of several upper mangroves tributaries of Bleesers Creek and a relatively large portion of the foreshore mangrove breeding sites along the Elizabeth River and mouth of Bleesers Creek (Warchot and Whelan, 2011). This is discussed further in Section 19.4 (Management of impacts).

19.3.1 Potential Impact to Health

Mosquito Borne Disease

The characteristics and risk of transmission of mosquito born diseases, identified as part of the Medical Entomology study that was undertaken as part of this assessment are summarised in Table 19-2.

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Table 19-2 Characteristics and Risk of Transmission of Mosquito Borne Diseases at EAW

Mosquito Borne Disease	Description and Risk of Transmission
Ross River virus disease *Symptoms can be debilitating and include joint pain, fever, lethargy, rash, headache and swollen glands, and can last for up to 12 months in some cases, although generally most people will have a severe illness from two weeks to three months (CDC Factsheet April 2003).*	• Most common arboviral disease in Australia and the NT (Russell and Kay 2004) (Whelan et al 2008). • The principal vectors *Ae. vigilax, Cx. annulirostris* and *Ae. notoscriptus* were recorded in appreciable numbers at East Arm. • Based on the likely abundance of the vector mosquitoes at East Arm, *Ae. vigilax* will pose a very high risk of transmission in December and January. This species may also pose an appreciable risk in other months such as October and November depending on seasonal rainfall, or high tides. • *Culex annulirostris* will pose a moderate to very high risk during the wet season months of January to April. • A*edes notoscriptus* will pose a relatively high localised risk during the wet season months, with work areas nearby to accumulations of exposed building and rubbish items at most risk.
Barmah Forest virus *Symptoms are similar to RRV, but are generally milder and BFV is not as common as RRV (CDC Factsheet May 2006).*	• The principal potential vectors recorded at the proposed development site were *Ae. vigilax, Cx. annulirostris* and *Ae. notoscriptus*. • Main risk months for BFV transmission are the months of October to July, with a peak in January to March, although transmission can occur during all months (Whelan 1997b). • The risk for BFV transmission will be similar to the RRV transmission risk at East Arm.
Murray Valley encephalitis virus *MVEV can cause a potentially fatal inflammation of the brain tissue. Symptoms include high fever, severe headache, seizures or fits (especially in young children), neck stiffness, drowsiness, confusion and progression to delirium and coma in severe cases (CDC Factsheet April 2004).*	• The principal potential vector of MVEV recorded at East Arm was *Cx. annulirostris.* • Main risk months for MVEV transmission are January to July with a peak in March to May (Whelan 1997b). • Based on the likely abundance of *Cx. annulirostris* at East Arm, the risk of MVEV transmission for an unprotected person is likely to be moderate to very high during January to March. • Only 1 in around 1000 people bitten by an infected mosquito is likely to develop disease symptoms, therefore the risk of contracting this disease is much lower compared to RRV and BFV.
Kunjin virus *Kunjin virus (KUNV) can potentially cause a fatal inflammation of the brain, but is much rarer than with MVE disease. KUNV typically causes a milder syndrome of severe headaches and fever and has not been responsible for fatalities in the NT (Russell and Kay 2004).*	• The KUNV risk at East Arm would be similar to the MVEV risk.

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Mosquito Borne Disease	Description and Risk of Transmission
Malaria *Endemic malaria is no longer present in the NT but there is always a risk of limited local transmission from people returning from overseas countries with malaria.* *It is highly unlikely that local malaria transmission will occur in the proposed development area, as long as prevention measures remain in place and new Anopheles breeding sites are not created by development.*	• *Anopheles. farauti s.s.* is regarded as the principal potential vector in the NT(Whelan 1995). • *An. annulipes s.l., An. hilli, An. bancroftii* and *An. amictus* are also potential vectors. • *An. farauti s.l.* and *An. hilli* can be seasonally present in relatively high numbers in the Darwin area, so these species probably pose the greatest risk in the Darwin area. • *Anopheles bancroftii* did reach levels likely to pose a low potential malaria risk during late wet season in 2010, while *Anopheles hilli* reached levels just above the risk threshold in the wet season. • Malaria transmission is more likely to occur if relatively high numbers of female *Anopheles* mosquitoes have bitten the malarious person, a high degree of personal exposure occurs, and there is a lack of effective vector control operations by health authorities. All of these factors are rarely present together in Darwin, and the likely low *Anopheles* mosquito abundance in most areas of East Arm indicates malaria transmission is potentially very unlikely. • In Australia, malaria is a notifiable disease. Each imported case in the NT is assessed and treated by a health professional, and monitored by Medical Entomology for the potential to cause local malaria transmission.

Source: Warchot and Whelan, 2011

Biting Midges Bites

Culicoides species bites can be a significant nuisance and can cause associated health problems. The bites are painful and large numbers of bites can cause a generalised reaction in non-immune people. Many people, particularly newly arrived or newly exposed people, suffer from bite reactions that can lead to intense itching, scratching, skin lesions, secondary infection and scarring (Warchot and Whelan, 2011).

The number of bites by *Culicoides* species that will constitute a human pest problem will largely depend on the individual being bitten. It has been suggested that over 60 bites per hour for workers regularly exposed to biting midge bites is unacceptable (Whelan et. al. 1997a).

For people unaccustomed to biting midge bites, one to five bites per hour may be unbearable (Warchot and Whelan, 2011). The amount of bites a person receives will be dependent on the amount of skin exposed and length of time spent outdoor in midge prone areas (Warchot and Whelan, 2011).

Warchot and Whelan (2011) suggest that very high pest problems may be encountered in all areas of East Arm within 1.5 km of the nearest mangrove margin. Trapping indicated levels of up to 21,000 *C. ornatus* in a single trap set over one night, with high pest levels starting at around 1000 *C. ornatus* per trap per night (Warchot and Whelan, 2011).

Peak season problems will occur from August to November, with appreciable pest problems expected during all other months (Warchot and Whelan, 2011). Peak biting times for *C. ornatus* are in the two hours either side of sunset and sunrise (Whelan 2003). This species also bites at relatively low numbers throughout the night (Logan et al 1991).

19.3.2 Potential Impact on Mosquito Habitats

Construction in tidal areas or on sites with some saline soil generally has the most potential to create productive mosquito breeding sites. Mosquitoes such as *Ae. vigilax* and *Cx. sitiens* will breed in very high numbers in disturbed upper tidal areas such as those created through site disturbance or the embankment of tide water.

Inappropriate site clearing and grading adjacent to tidal areas will create *Ae. vigilax* and *Cx. annulirostris* problems. All construction activities in tidal areas should therefore be carefully considered in the planning stage, and any previous or resultant disturbed areas appropriately rehabilitated upon completion of development (Warchot and Whelan, 2011).

Almost all of the current mosquito breeding sites at East Arm are a result of past development (Warchot and Whelan, 2011). Large and productive breeding sites for *Ae. vigilax* and *Cx. annulirostris* were located nearby to the wharf (Warchot and Whelan, 2011). These included two large, shallow remnant areas of Mud Pond A, and two large paperbark depressions as well as many ground pools located on disturbed land used for borrow material (Sections 5421 and 6117), nearby to the wharf (Warchot and Whelan, 2011). Sediment ponds with vegetation, as well as non-draining drains were also breeding sites for both of these mosquitoes (Warchot and Whelan, 2011).

Breeding sites for the receptacle mosquito, *Ae. notoscriptus*, were identified in building material and other items stored in yards nearby to the wharf guardhouse, and potentially on the wharf and in other

areas of East Arm. Breeding sites for *Ae. notoscriptus* are potential breeding sites for exotic dengue mosquitoes if an incursion occurs at the nearby wharf (Warchot and Whelan, 2011).

New breeding sites could be created due to the creation of borrow pits and scrapes, sediment ponds, mud ponds, some aspects of Water Sensitive Urban Design (WSUD), site clearing and reclaiming, stormwater drains and water discharge sites, road and railway construction over tidal areas, and inappropriate storage of artificial receptacles and materials that could pond water (Warchot and Whelan, 2011).

Future development has the opportunity to rectify existing mosquito breeding sites. Rectification of existing mosquito breeding sites will be of benefit to workers in the East Arm area, by reducing pest problems and the risk of mosquito borne disease transmission (Warchot and Whelan, 2011).

19.4 Management of Impacts

19.4.1 Objectives and Standards

DLP and DPC will continue to consult with Medical Entomology at the NT Department of Health (DOH) regarding requirements for managing and monitoring biting insects at EAW.

Medical Entomology has produced a number of guidelines to assist developers in planning developments in areas that are potentially productive mosquito breeding sites. These include:

- *Construction practice near tidal areas in the Northern Territory - Guidelines to prevent mosquito breeding (Medical Entomology*, 2009a).
- *Guidelines for preventing biting insect problems for urban residential developments or subdivisions in the Top End of the Northern Territory* (Medical Entomology, 2009b).
- *Constructed Wetlands in the Northern Territory – Guidelines to prevent mosquito breeding* (Warchot and Whelan, 2008).

Extensive information on midge avoidance and personal protection can be found in:

- Biting midges or sandflies in the Northern Territory (Whelan, 2003).
- Personal protection from mosquitoes and biting midges in the Northern Territory (Whelan, 2009).

Both of these documents are attached to the Biting Insect Report that was prepared by Medical Entomology as part of this assessment (**Appendix O)**.

Relevant legislation includes the NT *Public Health Act 2010*, and the associated *Public Health (General Sanitation, Mosquito Prevention, Rat Exclusion and Prevention) Regulations 2007*.

Australia is also bound by the World Health Organisation (WHO) *International Health Regulations, 2005* which have been enacted to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with, and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade (WHO, 2005).

19.4.2 Management Requirements

Mosquitoes

The report prepared by Medical Entomology (**Appendix O**) as part of this assessment includes specific recommendations in regards to filling borrow areas, site clearing/reclaiming, stormwater drainage, sediment ponds, mud ponds, WSUD and other activities that could lead to the creation of water ponding, along with information from the relevant Medical Entomology Guidelines (listed above).

A summary of mosquito management considerations contained in the report is presented below in Table 19-3. The report itself contains more detailed information on these recommendations as well as detailed recommendations in relation to rectifying existing sites.

Table 19-3 Summary of Mosquito Management Considerations in the Medical Entomology Report

Ongoing Management	• Business owners and landholders should annually remove unwanted artificial receptacles and rubbish items that could act as breeding sites for exotic dengue carrying mosquitoes. Building material and other material that could potentially pond water should be stored under cover, or in a manner that prevents ponding and receptacle mosquito breeding. Rainwater tanks and other storage tanks should be appropriately screened to prevent mosquito access. • Maintenance of stormwater drains and rectifying depressions on private lots, road and rail reserves and undeveloped land should be an ongoing management requirement for respective landholders.
Stormwater	• Stormwater drainage for the proposed development should be constructed in accordance with the *Guidelines for preventing biting insect problems for urban residential developments or subdivisions in the Top End of the Northern Territory* (Medical Entomology, 2009). • All new major open stormwater drains should have concrete low flow inverts, while roadside drains, swales and other minor drains should have concrete low flow inverts when the fall of the drain would not be enough to prevent ponding. • All roadside drains and swales should discharge to a suitable stormwater drainage system or directly to the sea. Major open drains should have concrete low flow inverts to the mangrove margin, and a free draining channel below the mangrove margin. • There should be no use of stormwater sumps in any roadside or local area drainage within the development site. Gross Pollutant Traps, Side Entry Pits, Letterbox Pits and any other stormwater pit should be free draining to prevent the creation of potential breeding sites for mosquitoes, including exotic dengue mosquitoes. • All drains should be placed on an annual inspection and maintenance program.
Culverts	• Culverts for roads and associated drainage should always be installed flush with the upstream invert of the creekline/flowline, to prevent the upstream impoundment of water and subsequent mosquito breeding. • If culverts are installed higher than the upstream surface level to allow for future reclaiming, then there should be appropriately sized drainage provisions provided to prevent upstream water ponding until the area is reclaimed. • Culverts should be installed with a slight 'V' invert to match the invert of any upstream and downstream drains, to prevent water ponding and minimise silt deposition in the culvert. Upstream and downstream open drains should also have V inverts.
Wetlands and Bioretention Systems	• Water Sensitive Urban Design structures such as wetlands and bioretention systems should be designed and maintained in accordance with the *Constructed Wetlands in the Northern Territory – Guidelines to prevent mosquito breeding* (Warchot and Whelan, 2008). All design plans should be submitted to Medical Entomology for informed comment regarding potential mosquito breeding issues.
Sediment Ponds	• Sediment ponds should be designed to be completely free draining, or be designed to have steep sides and contain deep water (>1m). • All sediment ponds should be placed on an annual maintenance program and maintained free of vegetation.

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Mud Ponds	• Any new mud pond should be constructed to contain deep water (>1m) and have steep sides, to minimise the potential for semi-aquatic vegetation growth and associated mosquito breeding. The installation of a water control device on the outlet culvert may assist in managing water levels in the mud ponds to prevent mosquito breeding. • Any new mud pond likely to only contain shallow water should be made free draining, which would include appropriately depositing sludge to minimise the creation of isolated pools and allow surface water to flow to the outlet culvert.
Reclamation / Construction	• Any cut off tidal area created during construction should have appropriate temporary drainage provisions provided, to prevent upstream ponding until the upstream area is reclaimed. • All new reclaimed areas should have a suitable surface profile to prevent ponding on the filled surface. • Borrow pits, scrapes, hill removal and other disturbed areas should be rehabilitated to be free draining. • Site disturbance such as wheel ruts and compacted ground should be rectified upon completion of construction, to prevent these areas from becoming perennial mosquito breeding sites.
Mosquito control	• If existing mosquito breeding sites at East Arm cannot be rectified before the next wet season, all landholders that have lots containing mosquito breeding depressions should be required to control any mosquito breeding. Methoprene 30 day residual pellets would be the insecticide of choice for most mosquito breeding sites at East Arm. Methoprene 150 day briquettes could also be used, especially in some existing sites where major extended mosquito breeding occurs.

Source: Warchot and Whelan, 2011

Biting Midges

The only way to effectively reduce *C. ornatus* breeding would be to permanently flood or fill their breeding sites, from the mean high water spring tide mark to below the level of occurrence of seaward mangrove (Shivas and Whelan 2001). If possible, more of the upper tidal tributaries of Bleesers Creek should be removed as part of the current proposed development (Warchot and Whelan, 2011).

Alternatively biting midge problems at East Arm could possibly be alleviated by the use of tidal bunds across upper tidal tributaries of Bleesers Creek, and also Hudson Creek (Warchot and Whelan, 2011). The use of tidal bunds however is speculative and would require intensive field trials to determine their effectiveness (Warchot and Whelan, 2011).

Consideration would also need to be given to the ecological impacts of removing mangrove habitats that support a suite of mangrove and wetland specialist fauna species, including small numbers of listed migratory shorebirds (Barden, 2011). This is discussed further in Chapter 16 and **Appendix M,** which contains the report for the Flora and Fauna Survey in support of this assessment.

The mangrove biting midge *C. ornatus* breeds in mud adjacent to and under dense mangrove canopies. Insecticide control of these sites is not practical, as very large quantities of insecticides would be required to penetrate the canopy and reach the mud below in sufficient amounts to achieve control. This would be unacceptable from an environmental perspective, due to the potential impacts to other organisms. There is also no registered insecticide product in Australia specifically suited to mangrove biting midge larval control (Warchot and Whelan, 2011).

As there is no specific larval control method for *C. ornatus*, affected people have to rely on reducing midge bites by personal protection measures or treatment of individual properties with a suitable residual barrier insecticide such as bifenthrin and alpha-cypermethrin. The use of insecticide 'hedge' barriers by individual landholders or along the outskirts of East Arm could provide effective control of

adult biting midges. However, any insecticide control option would require ongoing evaluation to determine if insecticide resistance is occurring. Any adult biting midge control program would also need to be funded and carried out by the relevant landholder (Warchot and Whelan, 2011).

Avoiding exposure to biting midges during peak monthly abundance around sunset and sunrise is the best form of personal protection. Other measures include the use of personal repellents and protective clothing such as long trousers with socks and shoes and long sleeve shirts. Yellow or red lights can be used in outdoor areas to minimise attracting biting midges (Warchot and Whelan, 2011).

Extensive information on midge avoidance and personal protection can be found in *Biting midges or sandflies in the Northern Territory* (Whelan, 2003) and '*Personal protection from mosquitoes and biting midges in the Northern Territory*' (Whelan, 2009).

East Arm is an industrial area therefore urban distance buffers from mangrove breeding sites, as found in some residential areas of Darwin and Palmerston, are not required. Trap results from October 2010 indicated reduced *C. ornatus* levels inland of the already present industrial lots. With the partial filling of some biting midge breeding sites and subsequent future industrial use, to some extent the inner areas of East Arm would experience lower biting midge numbers.

However, owing to the numerous and very high productivity breeding sites that will remain, pest problems are still likely to be seasonally high in all areas of East Arm until the majority of *C. ornatus* breeding sites are removed or altered to reduce breeding, or until a satisfactory adult biting midge control program is implemented (Warchot and Whelan, 2011).

In terms of using industrial lots as biting midge buffers, larger lots (>4000 m^2) are recommended adjacent to the mangroves, to minimise the number of people working in the worst areas for biting midges, and to promote land use such as storage or other activity that results in most of the lots being maintained free of vegetation (Warchot and Whelan, 2011).

All lots should have a notification on titles mentioning the high biting midge pest problems that occur at the East Arm Port Area and adjacent areas between the wharf and Hudson Creek east of Berrimah Rd (Warchot and Whelan, 2011).

19.4.3 Monitoring and Reporting

The relevant Landholders will be responsible for identifying wet season ponding areas for rectification, and maintaining stormwater drains and sediment ponds to prevent mosquito breeding.

Landholders will also be required to regularly inspect rainwater tanks and sites for unwanted artificial receptacles that could act as breeding sites for exotic dengue carrying mosquitoes. Any receptacle that has the potential to pond water will be appropriately disposed of, stored under cover away from rain, fitted with drainage holes or treated with an appropriate larvicide, to prevent endemic mosquito breeding.

Routine mosquito trapping is undertaken by the AQIS at EAW (Medical Entomology, 2010).

19.5 Commitments

- *Advise all workers that pest and disease-carrying mosquito species may be periodically present at the wharf.*

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- *Provide advice on appropriate personal protection measures and ensure appropriate personal protection equipment is available, in accordance with guidelines developed by the Medical Entomology Branch of the Department of Health. .*
- *Ensure that the construction and operational activities associated with the proposed expansion of EAW will be undertaken in accordance with the guidelines developed by the Medical Entomology Branch of the Department of Health and the recommendations included in this Draft EIS. Wherever possible the Proponent will seek to identify opportunities to rectify existing mosquito breeding sites as part of the proposed development.*
- *Ensure that Landholders regularly inspect sites to identify areas requiring rectification and maintain stormwater drains and sediment ponds to prevent mosquito breeding. Any insecticide control programs will be funded by the relevant landholders and subject to ongoing evaluation to determine if insecticide resistance is occurring.*
- *Ensure that Landholders regularly inspect rainwater tanks and sites for unwanted artificial receptacles that could act as breeding sites for exotic dengue carrying mosquitoes. Any receptacle that has the potential to pond water should be appropriately disposed of, stored under cover away from rain, fitted with drainage holes or treated with an appropriate larvicide, to prevent endemic mosquito breeding.*
- *Ensure that where possible larger lots that are free of vegetation will be recommended adjacent to the mangroves, to provide a buffer to minimise the number of people working in the worst areas for biting midges. Activities such as storage will be promoted in these areas.*
- *Ensure that all lots will include a notification on titles mentioning the high biting midge pest problems that occur at the East Arm Port Area and adjacent areas between the wharf and Hudson Creek east of Berrimah Rd*

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